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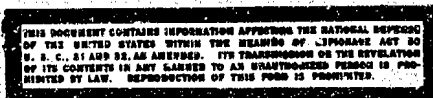
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HOLE-DRILLING MACHINE TOOL SAVES FUEL

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[Numbers in parentheses refer to machine-tool parts in Figures 1 and 2, appended.]

Many diesel-electric power plants undertake the drilling of fuel-injector nozzle holes in a makeshift manner which results in excessive consumption of fuel. To correct this situation a description of an extremely accurate machine tool used for drilling fuel-injector nozzle holes is presented here. The procedure for checking the distribution of the fuel jets is also explained.

General Description

The spindle (7) rotates on two ball bearings. When the nuts are tightened these ball bearings eliminate play in the spindle. The ball bearings are inside a hollow stock (6), which slides without play in an iron sleeve (4) set firmly in a cylinder (5) which is secured to the base (1) by a welded rib.

The stock, which has a rack gear on the bottom, is connected with a pinion (2), the turning of which effects hand feeding of the stock and spindle. Mounted on one end of the spindle is a pulley (3), the length of which permits readjustment of the belt with the spindle in any position. There is a thread on the other end of the spindle for mounting the chuck, which consists of a tightening nut (8) and two sliding blocks (9) which hold the drill.

The internal surface of the nut is conical, corresponding to the form of the sliding blocks. On the end of the spindle, exclusive of the threading, there is a cylindrical part 48 millimeters long. On this part a hollow center punch (16) is mounted after the chuck has been removed.

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The cylindrical end of the spindle is ground down by a slotted, cast-iron disc, using paste, while the trueness of the cylinder is checked with a micrometer.

The center punch is ground to the diameter of the spindle, but grinding in place is not permitted. There should be no perceptible play of the center punch on the spindle.

The demands for accuracy in the manufacture of the chuck are also high; the exterior conical surfaces of the sliding blocks are fitted to the tightening nut with such precision that when a small piece of straight steel wire is held in the chuck, rotation will not cause a deflection of the indicator-needle of more than .02 millimeter, while the measuring jaws remain close to the spot where the wire is clamped.

Graduation marks, filed on the sliding blocks with the edge of a triangular file (after marking out), serve as a place for clamping the wire or drill. Before marking with the punch, the place on the part is leveled off by a special attachment (17) which is screwed onto the end of the spindle and which resembles a center punch with a blunt end.

Leveling off is necessary because, unless a small flat spot, perpendicular to the axis of the spindle, is made on the part, the drill goes off to one side.

A cylinder with a conical tail (13) is substituted for the specified factory-design cone of the spacing attachment. The cylinder has an accurately ground blind hole, into which the piston (10) fits. The piston has a place on the end for securing the parts, and a tightening nut (11) (the form depends on the design of the parts). Along the side of the piston is a longitudinal V-shaped groove, into which the end of the needle (12) fits, stopping the plunger. The machine tool makes about 7,000 revolutions per minute. Increasing the revolutions does not increase the accuracy of drilling, and is harmful to the cutting edge of the drill.

Adjustment of the Machine Tool

By means of the indicator, the cylindrical part of the stock is adjusted for parallelism to the smooth plate, which serves as a support for the stand. The end of the center punch is checked by the indicator, and is then ground sufficiently to limit the play to 2 - 3 microns, after which it is flame-heated by an autogenous burner until incandescent. After tempering, a second adjustment of the indicator may be needed, as well as a final adjustment of the end of the center punch with a small hone.

The axis of the spindle must lie in the plane of vibration of the axis of the piston. To check this, an attachment (19) is fitted to the piston.

After the adjustment (by hand grinding) of the sharp end of the attachment, before the elimination of play by turning the spacing attachment in a vertical plane, the plunger is placed in either of two extreme positions, the sharp ends of the attachment and the center punch are drawn together, and, by a shift in the base of the spacing attachment, are brought into almost complete contact. It is necessary to attain this almost complete contact in the vertical plane at the other extreme position of the spacing attachment as well (within the working range of the angles of turning).

If several holes are drilled in the part at various angles to the vertical, then care must be taken to insure that the piston does not turn about its own axis when it is advanced to any position and secured in place by the stopper needle. It is therefore necessary that the groove along the side of the piston be parallel to the axis of the piston.

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To check the piston, an attachment (20) is used, with the cylinder in either of the extreme positions. On the side of this attachment a shallow mark is made with the center punch. After turning the spacing attachment through a vertical plane to the other position, the center punch is advanced to the mark, and attempts are made to have the ends of the attachment and of the center punch coincide.

If the points do not coincide, one side of the groove is ground out at the required spot, and a trihedral ruler is used for checking.

Preparation of the Drill

Factory-made spiral drills are used, as well as pointed drills which can be made by hand. The spiral drills are somewhat more accurate for aligning holes, and it is therefore preferable to use them, for example, for drilling the holes in the fuel-injector nozzles for the lower concave crowns of the cylinder in double-action diesels.

The diameter of both the spiral and the pointed drill should be 15 microns less than the diameter of the hole. For holes less than .35 millimeter in diameter, the drill must have a diameter of from 5 to 10 microns less. Since it is difficult to sharpen the spiral drill without a special machine tool, when the cutting edge becomes dull it is better to replace the drill with a new one.

Pointed drills are made from steel wire, such as guitar wire. Their diameter is .5 to .10 millimeter less than that of the hole. A small piece of this wire is rolled with a barrette file on a flat plate for straightening, freed by breaking the adhesion with a small mallet, and hand sharpened on a small hone of the "India" or similar type, then heated over a spirit lamp and placed while incandescent in machine oil. It is then given a final sharpening, and is examined through a lens to see that both cutting edges look the same. The point angles are similar to those on regular drills, or a little more obtuse.

Drilling of metal may be carried out at a very low speed while the drill is well sharpened.

Operation of the Machine Tool

The spacing attachment is set at the required angle in a vertical plane.

The part being worked over is secured to the end of the piston, and the spot to be drilled is fixed on a level with the axis of the spindle.

An attachment (17) is secured to the end of the spindle. Applying it to the part by means of the rack gear, and moving the small belt by hand to turn the spindle, a flat area is made on the part.

This attachment is removed and the center punch is put on the end of the spindle in its place.

Applying the center punch to the part by means of the rack gear, and turning the spindle in the same fashion as before, we make an indentation on the part.

The center punch is then removed and replaced by the chuck, in which the drill is secured by the locking nut. The drill must protrude 5-10 millimeters from the chuck. After the machine has been started and it has been determined that there is no play in the drill, the rack and drill are raised out of the hole. Instead of employing periodic drilling for cooling the drill, drops of water are allowed to fall on the end of the drill from a small wooden stick.

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The diameter of the hole is checked when the drill is moved back. Two gauges, made from small pieces of steel wire whose ends have been compressed by blows from a small hammer, and carefully measured on the edges with a micrometer, are used for this check. The first gauge, having dimensions exactly corresponding to the required diameter of the hole, must fit completely into the hole, while the second, 5 microns greater in diameter, must not fit into the hole, or ever partly penetrate it. In this way a check on the trueness of the cylindrical form of the hole is insured. If the first gauge does not fit into the hole, then the hole is drilled once or twice more with the same drill. In extreme cases a larger drill is used in its place.

Checking Alignment of the Holes

Even if the above measures for adjusting the machine tool are taken, corrections are almost unavoidable in obtaining the maximum approximation to the desired alignment.

The best method of finding error is to pump a stream of liquid, such as oil, through the openings with a plunger press, after mounting the part in a vessel whose walls have been marked by points which the streams should strike.

In case the streams go to one side of the points marked, then the steps that must be taken to complete the correction will become apparent.

It is quite permissible to change the angles of the directions of drilling, departing from the given design, provided the target is hit.

It should be remembered that the distribution of the streams must be checked before the projecting edges where the drill entered the hole are trimmed. The liquid must be filtered, and the holes must be cleaned several times with a small needle during the pumping process. An accuracy of one fourth of a degree is completely attainable with the machine tool described above.

A more convenient chuck of different design (18) can be used with an accurate machine tool for drilling out holes in which the drill has become stuck.

The machine tool was designed by the author of this article in 1944-1945, and was tested in actual performance. The greatest innovations are means for smoothing off the spot punch and the center punch which assure particular accuracy in drilling.

For drilling holes uniformly spaced according to the roundness of the part, and not varying in angle of inclination, the spacing attachment may be simplified in design, and made by hand (e.g., in drilling holes in the fuel injector for ordinary single-action diesels). In that case the work of drilling is simplified, and space is not needed to remove the center punch and to set up the drill after punching for each opening.

[Figures follow.]

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Technical drawing of a mechanical device, likely a pump or valve assembly. The drawing includes a side view and a cross-sectional view. The side view shows a curved component (1) with a central shaft (2) and a piston (3) inside a cylinder (4). The cross-sectional view shows the internal components, including the piston (3) and the cylinder (4). Various parts are labeled with numbers 1 through 14.

Figure 1

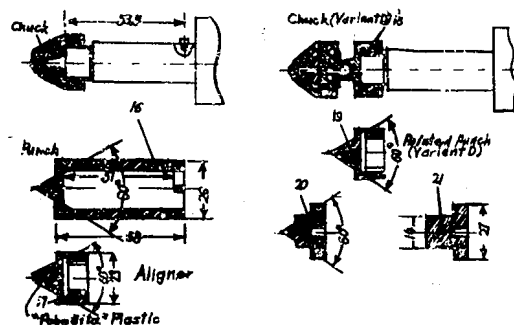


Figure 2

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